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Tannin cells of persimmons

BURTON JAMES HOWARD

The fact that the tannin in persimmons becomes highly localized during the process of ripening was pointed out by the Japanese investigator Aso * in 1900. He calls the cells "tannin sacs," but all he mentions concerning them is that the tannin is stored in large cells, and he accredits its deposition largely to the action of an oxydase. He also indicates that a browning of the tannin mass also occurs. A still later article upon the subject is that of Tichomirow,† in which certain microchemical characteristics of the bodies are brought out, but apparently this author worked only on ripe fruits, for none of the progressive changes during ripening are noted. Because of the meagerness of some of the facts given it was deemed well to look somewhat further into this phenomenon in connection with chemical work being undertaken by the Bureau of Chemistry, because it was thought it might shed some light on some of the chemical results obtained. Cells of a form somewhat similar to those present in persimmons are present in the Saint John's bread (*Ceratonia Siliqua*) and here also serve for the deposition of tannin. At a recent meeting of the Washington Botanical Society, Mr. Walter Swingle described such cells, occuring in the flesh of the date, which he termed "giant cells" because of their great size.

We have chosen to call these cells tannin cells, for though in some varieties they are very large, yet in others they vary only little from the other parenchyma-cells in their vicinity. In the persimmon the tannin cells occur in the wedge-shaped portions of flesh between the carpels. They appear simply as specialized parenchyma-cells, from which they differ hardly at all excepting in size in the earlier stages of ripening. The shape and size of the tannin cells vary widely in the American, Chinese and Japanese types. In the wild persimmon varieties of eastern North America, the cells are about the same size and shape as the other parenchyma-cells around them, being nearly isometric in shape (FIGURE 1). The Chinese variety, which was kindly sent us by Mr. Taylor of the Office of Pomological Investigations, was found to contain an immense number of these cells, which were not very greatly different from those found in the American type, though commonly somewhat pointed at the ends (FIGURE 2). The most remarkable tannin cells both as regards size and shape occur in the Japanese varieties. In this type the cells are commonly cigar-shaped, in some cases being five or ten times as long as wide and having an actual length of one millimeter or more (FIGURE 3). If a small portion of the soft pulp from a thoroughly ripened fruit is spread upon a slide or allowed to flow down the side of a test tube, the individual cells can easily be seen with the naked eye. These differences as shown in the different kinds are of especial interest in

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* Aso: A physiological function of oxydase in Kaki-fruit. Bot. Mag. Tokyo 14: 179. 1900.

† Tichomirow: Sur les inclusions intracellulaires du parenchyme charnu de certains fruits. Compt. Rendus Acad. Sci. Paris 139: 305. 1904.

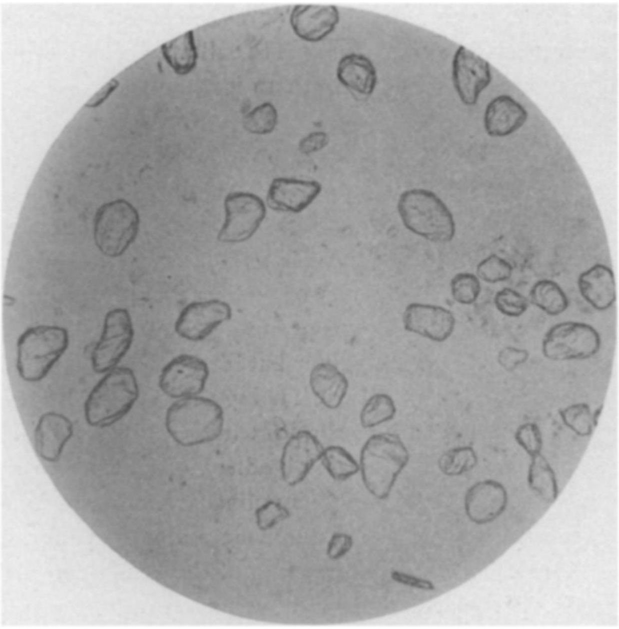

FIGURE 1. Tannin cells from wild American persimmons. × 25.

view of somewhat similar differences occurring in different kinds of dates, as was pointed out by Mr. Swingle.

In portions of the tissue where these cells occur in great abundance there seem to be special modifications in shape by which nearly adjacent tannin cells are in touch with each other. This is accomplished by small protuberances extending from one cell toward another of like character meeting similar projections from the other cell midway. This is shown in FIGURE 4. Such arrangement seems very manifest in the Japanese variety, from which the illustration was made. The actual communication between the cells seems to be no more free than is usual among parenchyma-cells, inasmuch as only pore-like perforations appear to be present.

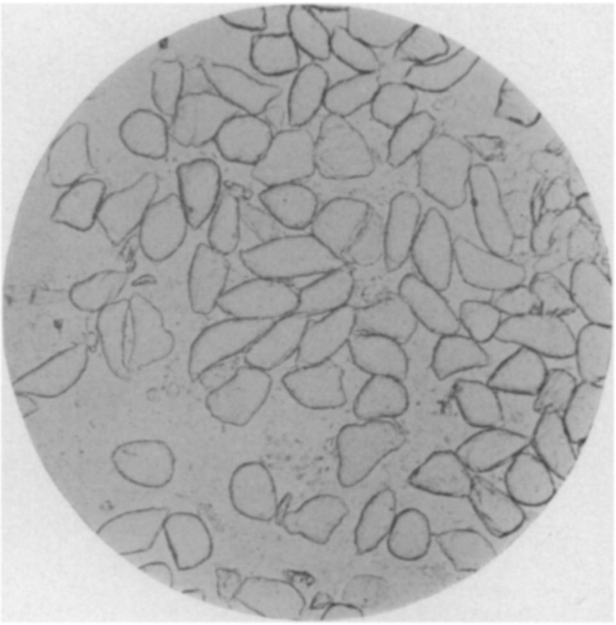

FIGURE 2. Tannin cells from Chinese persimmons. × 25.

For the sake of convenience of description, the ripening process of persimmons may be divided into three stages which shade off by imperceptible degrees from one into the other, viz: the green, the transitory, and the ripe.

In the green stage the tannin does not appear to be strongly localized, for though it appears most abundantly in the loose parenchyma-tissue where the tannin cells are located, yet it is not limited to these cells nor even to the region where the cells are most abundant. Microchemical tests show that tannin is abundant in most of the cell-sap of the parenchyma-cells and even in the intercellular portions. In this stage it is somewhat difficult to identify the cells which are afterwards to figure as tannin cells except by means of the size and shape, which as noted above strongly differentiate them in some varieties. At this stage the cell-contents appear to be in as perfectly liquid condition as any other cells around them.

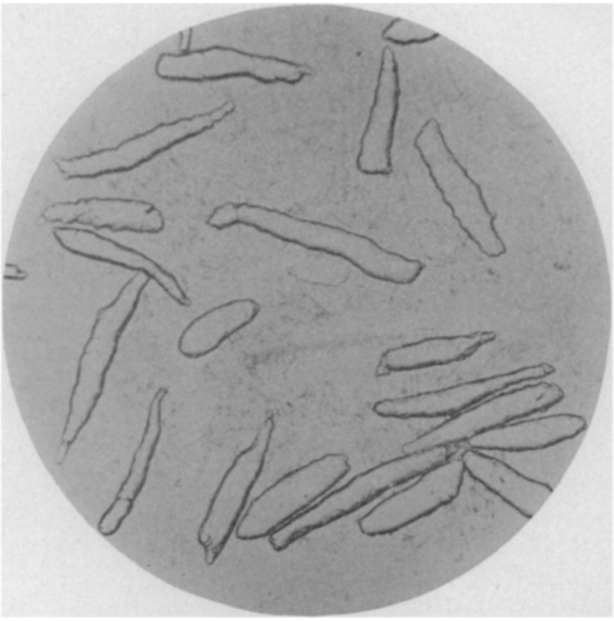

FIGURE 3. Tannin cells from Japanese persimmons (Kaki). × 25.

The second stage of ripening, the transitory, is the one in which the most radical changes occur in the physical and possibly in the chemical constitution of the tannin. This stage in the native American variety is signalized by a slight decrease in the firmness of the fruit, and not long afterward by a marked tendency toward softening. Examination of the tissues in the early part of this stage will show that most of the tannin is being or has been collected into the tannin cells. The contents of the cells are becoming more highly refractive and from this fact the cells can be identified with considerable ease, even without any tannin test. The middle lamellae have softened sufficiently to allow the cells to be separated without rupturing the walls. At about the middle of this stage a large proportion of the tannin cells show vacuoles between the tannin mass of the cell and portions of the cell-wall (FIGURE 5).

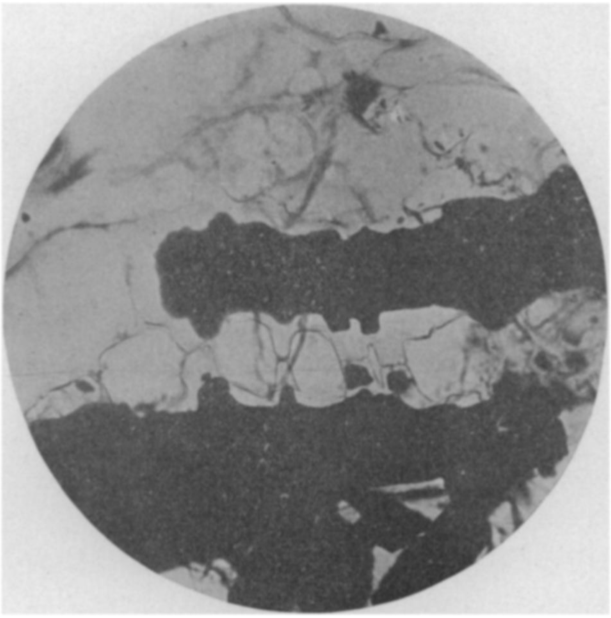

FIGURE 4. Section of Japanese persimmon, showing projections extending between adjacent cells. Tannin cells (masses) dark and somewhat shrunken away from the cell-wall. × 150.

If the material is mounted in the fruit juice these vacuoles remain unchanged, but if water be added the tannin mass expands, fills out the vacuoles, and, if allowed to continue absorbing, there results a rupturing of the cell-wall. This is then followed by part of the cell-contents being forced out into the surrounding media. In the early part of this stage the contents thus escaping mingle readily with water, but later on the material forms a globular-shaped portion on the sides of the cell. Such a condition is shown in

FIGURE 6. There is no definite portion of the cell-wall where rupture occurs; sometimes this happens at one end and at other times at some point along the side of the cell. The form of energy producing the bursting is undoubtedly osmotic pressure, for solutions of fairly strong osmotic power cause no increase in size or bursting when pulp cells are mounted in them. In order to demonstrate this we used glycerine solutions as well as aqueous solutions of sodium chloride, potassium bromide, potassium iodide and sodium sulphite. Even the tannin reaction with fairly strong iron chloride solution proceeds with exceeding slowness where rupture of some kind has not occurred. It appears that if the iron chloride solution is about isotonic with the solution within the cell, sufficient water cannot pass in to produce rupturing and thus bring the cell-contents in contact with the reagent; and furthermore that the iron salts are prevented, except in comparatively few instances, from passing into the cells and producing the color reaction there.

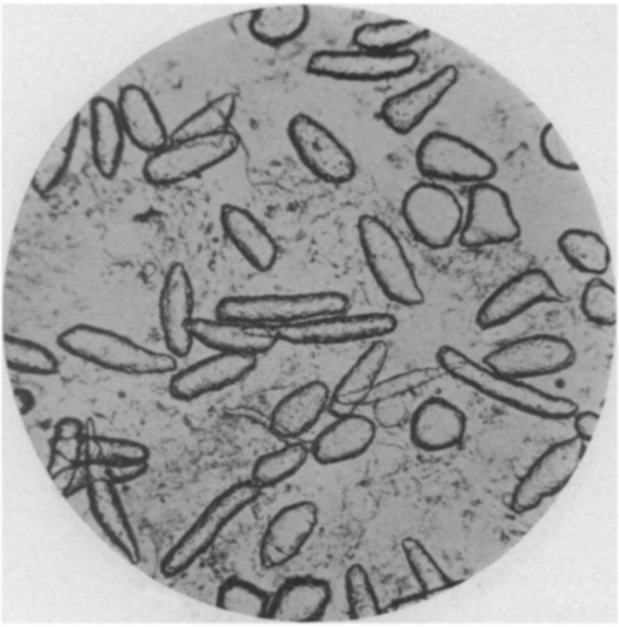

FIGURE 5. Japanese persimmon tannin cells (masses), showing small vacuoles on surface. × 25.

The above facts show very convincingly why it is that in eating partially ripe persimmons they first produce a fine sweet taste, while it usually takes about half a minute for the taste to detect any astringency; this of course being due to the fact that the saliva, being a liquid of low osmotic strength, causes in a few seconds a swelling and rupturing of the tannin cells and finally the consequent development of astringency. Fruit-pulp in this stage of development if mixed with water changes only slowly. When rupturing and contact with water has finally occurred there appear after a short time, even to the naked eye, whitish particles. These on further examination are found to be the expelled cell-contents, which on coming in contact with abundance of water have assumed a white granular condition.

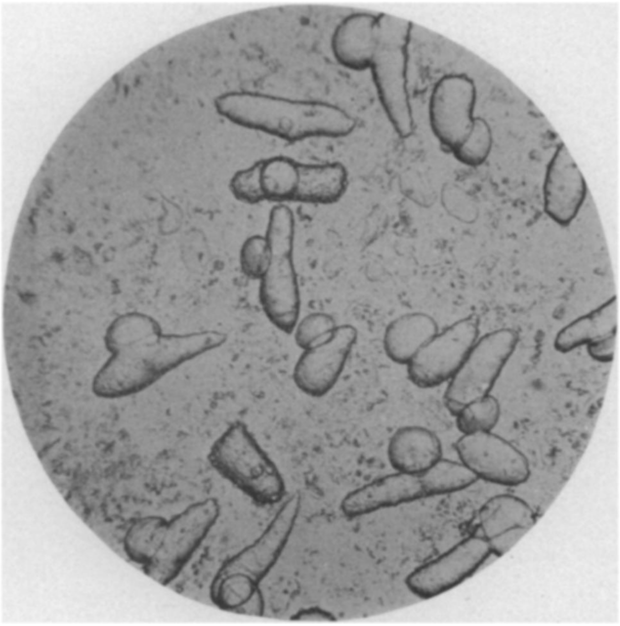

FIGURE 6. Tannin cells after bursting, showing tannin globule on side of cells. × 25.

The writer has also observed that solutions considerably stronger than those necessary to maintain equilibrium will produce a shrinking of the cell-contents. This is of course what might be naturally expected when the cause of the swelling is considered.

When the last stage of the change has been reached the tannin masses have a very high refractive power. The addition of water causes but little, if any, swelling, and the contents are friable, pressure upon the cover slip resulting in the fracturing of the tannin mass into irregular fragments (FIGURE 7). These fragments tested for tannin give strong reactions showing that no fundamental change has taken place in the distinctive character of the tannin radical. This stage of ripening is evident to the taste, for all astringency has now disappeared. Right here it may not be out of place to call attention to the fact that finally the tannin masses may be either of watery clearness in color or else of dark amber-brown color. There is, however, a difference in surface outline of the two kinds, in that the clear form has a fairly even surface with more or less of slight wrinkling while in the brown type hemispherical hollows in the surface seem to be always present in greater or less extent (FIGURE 8). Hollows are very rarely observed in the clear type. The brown type has not been observed

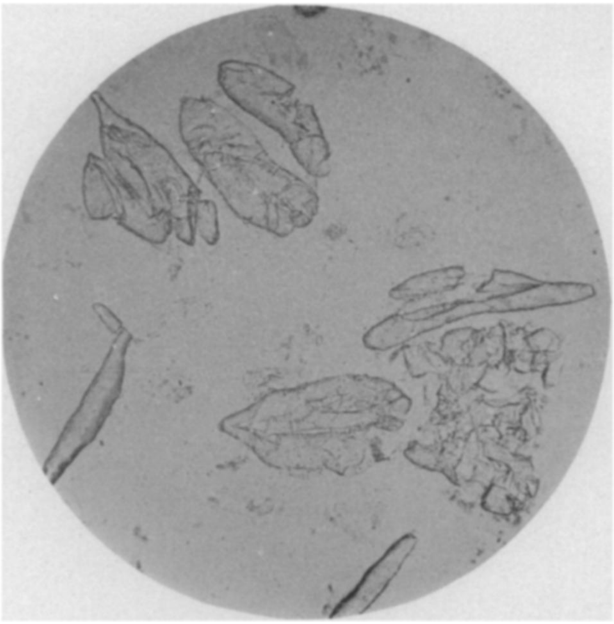

FIGURE 7. Tannin cells in ripe condition, after pressure has been applied, breaking the mass into fragments. × 25.

in any of the wild American fruits. The brown-colored cells are much harder than the clear type, giving in the process of mastication almost the sensation of the stone-cells in some fruits. The reaction with tannin reagents develops more slowly in this than in the clear kind. The brown type of the tannin mass is the only one referred to by Aso, and he considers that it is a result of an oxidation occurring in the tannin during the process of deposition. The present writer, however, fails to see that any such change in color is of necessity connected with the localization of the tannin, but rather thinks that it indicates secondary changes which have occurred after the deposition of the tannin has been completed.

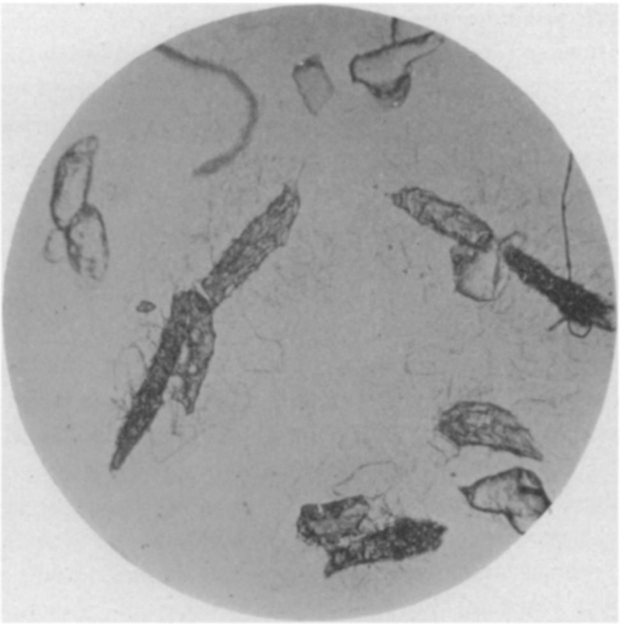

FIGURE 8. Brown tannin masses (cells), showing depressions or hollows. × 25.

In a few Japanese persimmons sent from the Alabama Experiment Station only one showed these brown tannin masses even when the fruit was firm and strongly astringent. They were also present in the sample furnished by Mr. Fairchilds which had been cured in saki barrels, but we are inclined to believe that the saki had nothing to do with their presence there.

Experiment also demonstrated that fruit packed in a container with vapors of chloroform lost its astringency much quicker than those simply kept in a container without the chloroform, but there was developed at the same time a marked increase in the degree of mushiness.

Another feature which is commonly associated in our minds with the ripening of persimmons, is the development of mushiness. This feature, however, does not run parallel, stage for stage, with changes in the tannin, for it not infrequently occurs that mushiness develops before the astringency is gone, while in other cases just the reverse is true. The latter case is notably so in specimens artificially cured by the saki process. In this method, which is largely employed by the Japanese in ripening their varieties, the fruit is stored for a few days in empty saki barrels. At the end of the treatment it is found that the tannin has all been localized and rendered insoluble in water, though the flesh of the fruit is nearly as firm as that of an ordinary apple. From this it seems that the change in the physical characteristics of the tannin is not at all closely related to the development of mushiness. This makes highly improbable a hypothesis, which we at first thought might be true, namely, that as the middle lamella was rendered soluble in the process of ripening it in some way combined with the tannin, producing a compound insoluble in water. Mr. Gore, of these laboratories, in his studies into the chemical changes occurring during the process of ripening of persimmons, has demonstrated that the sum of tannin and marc (pulp less alcohol-soluble matter) is nearly a constant throughout the process of ripening; from which it seems improbable that the tannin combines with any soluble substance, such as sugar, producing an insoluble compound; for, as shown above, the tannin to the end of the ripening process maintains its power of color reaction toward tannin reagents such as iron salts and chromic compounds.

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